INK JET PROCESSES

BACKGROUND

[0001] The present method in embodiments generally relates to ink jet printing. More particularly, the present method relates to detecting one or more improperly functioning ink jets and compensating for the improperly functioning ink jets with the remaining operational ink jets.

[0002] In ink jet printing, usually each jet of a print head within a printer is assigned the role of ejecting ink, as necessary, onto pre-specified areas which is currently in a jet's respective print zone. However, a jet sometimes improperly functions, fails, or substantially fails, that is the jet is unable to properly emit ink drops, examples of which may be due to either being clogged or electrical problems in its firing circuitry. When this occurs, the pre-specified areas that are assigned to the failed jet are not printed upon or not printed on properly. If one or more jets fail, the quality of the printed image may suffer and in some instances not be acceptable to a number of sources. Therefore, a need exists that allows for the end user of a printer to detect and enable software to substitute failed jets quickly, enabling continued operation of the printer with acceptable print quality. The ability of the end user to immediately substitute failed or improperly functioning jets may also allow more flexibility in the timing of a service call to repair the printer, since the printer has acceptable print quality. Redundancy, replace-ability and disposability are all common methods of using components that are unreliable or that wear out to build commercially successful products. Use of a jet substitution mode may be appropriate for print head technology, due for example, or in part to the long overall head life and the very large number of jets per head.

SUMMARY

[0003] Disclosed are methods for compensating for failed, substantially inoperative, ink jets in an ink jet apparatus. The method in embodiments determines if one or more ink jets have improperly functioned and compensates for the one or more improperly functioning ink jets by using one or more operational ink jets. The operational ink jets used are neighboring operational ink jets that fill in for the one or more improperly functioning ink jets. The one or more improperly functioning ink jets are disabled wherein a primary image pass is performed followed by one or more additional imaging passes to fill in for the one or more disabled ink jets by enabling the one or more neighboring operational ink jets. The additional imaging passes may be a right fill imaging pass, a left fill imaging pass or a combination of both.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] The drawings are not to scale and are only for purposes of illustration.

[0005] **FIG. 1** is a block diagram of the components of an ink jet printer system;

[0006] **FIG. 2** illustrates an isometric view of the ink jet printer system shown in **FIG. 1**;

[0007] **FIG. 3** illustrates an example of a diagnostic test print;

[0008] **FIG. 4** diagrammatically illustrates jet usage during jet substitution;

[0009] **FIG. 5** graphically illustrates an example of how jets deposit ink during imaging;

[0010] **FIG. 6** is a flowchart for the method of determining if jet substitution should be used;

[0011] **FIG. 7** is a continuation of the flowchart of **FIG. 6** for the method of enabling and disabling missing jet substitution; and

[0012] **FIG. 8** is a continuation of the flowchart of **FIG. 7** for missing jet substitution.

DETAILED DESCRIPTION

[0013] Methods are disclosed for detecting if at least one jet in a device has failed to function or is improperly functioning and substituting the jet with at least one operational ink jet. The methods disclosed herein for detecting and substituting non-functional ink jets may be designed for use in printers, such as solid ink color printers but may also be used in other printing technologies using an array of imaging elements. The printer uses an offset printing process and piezoelectric print head technology that jets molten solid ink. **FIGS. 1** and **2** show an imaging apparatus **10** subassembly for a printer utilized in this process to transfer an inked image from an intermediate transfer surface to a final receiving substrate. A print head **11** is supported by an appropriate housing and support elements (not shown) for either stationary or moving utilization to place an ink in the liquid or molten state on a supporting intermediate transfer surface **12** that is applied to a supporting surface **14**. Intermediate transfer surface **12** is a liquid layer that is applied to supporting surface **30**, such as a drum, band, platen, or other suitable design, by contact with an applicator, such as a metering blade, roller, web, or wicking pad contained within an applicator or blade metering assembly **16**.

[0014] Applicator assembly **16** optionally contains a reservoir **18** for liquid application and most preferably contains a roller to periodically present oil to the drum **30**. Applicator apparatus **16** is mounted for retractable movement upward into contact with the surface of drum **14** and downwardly out of contact with the surface of the drum **14** and its intermediate transfer surface or liquid layer **12** by means of an

appropriate mechanism, such as a cam, an air cylinder, or an electrically actuated solenoid (not shown).

[0015] In this process, a solid or hot melt, ink is placed into a heated reservoir (not shown) where it is maintained in a liquid state. This highly engineered ink is formulated to meet a number of constraints, including low viscosity at jetting temperatures, specific viscoelastic properties at drum-to-media transfer temperatures, and high durability at room temperatures. Once within the printhead **11**, the liquid ink flows through manifolds to be ejected from microscopic orifices through use of piezoelectric transducer (PZT) printhead technology. The duration and amplitude of the electrical pulse applied to the PZT is very accurately controlled so that a repeatable and precise pressure pulse can be applied to the ink, resulting in the proper volume, velocity, and trajectory of the droplet **26**. The individual droplets **26** of ink are jetted onto the liquid layer **12**, which is supported by a rotating drum **30**. The drum **30** and liquid layer **12** are held at a specified temperature with the use of a drum heater (not shown) such that the ink hardens to a ductile viscoelastic state. After the entire image has been jetted onto the liquid layer **12** on the drum surface **14**, it is transferred and fixed, or transfixed, onto pre-heated receiver media **21** (paper, transparency, etc). A high durometer synthetic pressure roller **23**, when placed against the drum **14**, develops a high-pressure nip **22** that compresses the paper and ink together, spreads the ink droplets **26**, and fuses the ink droplets **26** into the media **21**.

[0016] Referring once again to **FIGS. 1** and **2**, a final substrate guide **20** and media preheater **27** passes a final receiving substrate **21**, such as paper, from a positive feed device (not shown) and guides it through a nip **22** formed between the opposing actuated surfaces of a roller **23** and intermediate transfer surface **12** supported by drum **30**. Stripper fingers or blades **24** (only one of which is shown) may be pivotally mounted to imaging apparatus **10** to assist in removing final receiving substrate **21** from intermediate transfer surface **12**. Roller **23** has a metallic

core, preferably steel, with an elastomeric covering and engages final receiving substrate **21** on a reverse side to which an ink image **26** is transferred from intermediate transfer surface **12**.

[0017] Referring now to **FIGS. 2** through **4**, the microscopic orifices **54** of printhead **11** are arranged in rows for emitting color ink in a CMYK (cyan, magenta, yellow and black) scheme wherein each color orifice is separated a distance **58** by column **56**. Image rendering and handling software commands a print engine (not shown) located as part of the printer **10** to enable or disable user-selected jets. The image rendering and handling software contains one or more Page Description Languages (PDL), such as PostScript, as well as a front panel control (not shown) located on the exterior of the printer for user interaction. This enabling and disabling can be done either through front panel controls or through the use of print jobs using product specific commands. Once the user selected jets are determined to be nonfunctioning or to have failed **62** and one or more non-failed jets **60**, **64** neighboring the failed jet are able to substitute for the failed jet **62**, subsequent print jobs will command the print engine with a flag indicating whether or not the print engine may perform failed jet substitution. The default print command is for the print engine to perform jet substitution when one or more jets are disabled. User developed print files may command the printer to not perform jet substitution.

[0018] More specifically, an imaging pass is defined as the motion of the printhead as it moves **42** across the drum **14** at X pixels per unidirectional drum revolution **15** for N rotating drum revolutions. X has values of one (1) or greater, limited by the amount of head travel **50** available. When X is greater than one, vertical image rasters, parallel to the feed direction of the media **19**, are deposited in an interlaced fashion on the drum **14** since each jet will pass into the area where the neighboring jet deposits ink. In some cases, one or more additional head positioning adjustments are made during imaging to avoid one jet depositing ink where another jet has already deposited ink. An example of a two pixel interlace (X=2) with a single pixel

positioning adjustment after the 7th drum revolution is shown in **FIG. 5**. N is determined by two factors: the physical spacing of the jet orifice columns **58** on the front of the print head and the horizontal resolution **50** of the printed image.

[0019] During each drum revolution **15**, each individual jet orifice emits ink of an assigned color creating a scanline **56**, or vertical image raster, of that particular color on the surface of the drum **14**. Since there are groupings of jets that are lined up vertically in a column, with one of each of the ink colors in that column, each scanline deposited during that drum revolution will be completely imaged. These scanlines are parallel to the feed direction of the media. As each additional drum revolution **15** is performed, more of the image is placed on the drum surface. Once all drum revolutions have been performed for the imaging pass, all ink for the imaging pass has been deposited on the drum surface, resulting in a completed image on the intermediate transfer layer **12** on the printing substrate **19**.

[0020] The primary imaging pass is the first imaging pass in which all enabled jets are used to deposit ink on the drum. If there are no disabled jets, the image on the drum will be complete. If there are disabled jets and jet substitution is being performed, the primary imaging pass will deposit ink on the drum only for the enabled jets. One or more secondary imaging passes will be performed after the primary imaging is complete to fill in where the disabled jets should have deposited ink during the primary imaging pass using only neighboring jets.

[0021] A further detailed description of the methods in embodiments will now be more fully described using the flowcharts shown in **FIGS. 6** through **8**. With reference to **FIG. 3** when the user notices print artifacts on printed pages **90**, characterized by missing ink or incomplete ink coverage and often seen as unexpected white streaks on the page, they will execute a diagnostic print **92.** As shown in **FIG. 3**, the jet diagnostic print is used to determine **94** if and which jets are failing **62**. If no jets are found to be defective **96**, then the user will ensure all jets are enabled and resume normal printing operation **98**.

[0022] However, if the user finds **96** on the test print that one or more jets that are not functioning properly, indicated by visually by, but not limited to, no ink present, incomplete ink coverage, or improperly positioned ink, then the user will initiate a head cleaning sequence **102** using the front panel to attempt to recover the failed jets. After each cleaning **106**, a diagnostic test page is printed for the user. If the failed jets are not recovered, or the image quality remains unacceptable, the user will repeat the cleaning steps a given number of times or until the failed jets are recovered. If cleaning the printhead resolves **100** the problem, then the user will ensure all jets are enabled and resume normal printing **98**.

[0023] If cleaning the printhead does not resolve the problem, then the user will contact **104** technical support for assistance. If it is determined **108** that jet substitution should be used, the user, through the use of the front panel or custom print files, will enable jet substitution by commanding the printer to disable the selected failed jets and to substitute the ink the disabled failed jets normally emit during the primary imaging pass **66** using operational neighboring jets **60** or **64** during one or more secondary imaging passes **70** and **74**, as shown in **Fig. 4** and more fully described below.

[0024] Referring to **FIG. 7**, to disable and enable jets, the user accesses a front panel menu **112**. The user then selects **114** one of the colors based on the diagnostic print results. In this case it is Cyan, Magenta, Yellow, or Black. The user then selects **116** the number of the jet based on the diagnostic print. The user determines **118** if there are more problem jets that need to be disabled and if there are continues the selection process until finished. The user now exits the front panel menu and resumes printing **120**.

[0025] Referring to **FIG. 5,** if no jets are disabled, then the standard motion of the printhead is used. This is a single pass **76** of the printhead across the imaging drum using all jets and may be referred too as the primary imaging pass **82**. If one or more jets are disabled and jet substitution is enabled, then a primary imaging pass **82** is

made with all enabled jets used, and then one or more secondary imaging passes (**84** or **88** as will be more fully described below) are made with only the neighboring substitution jets being used.

[0026] More particularly and turning to **FIG. 8**, when the image rendering and handling software begins the imaging process, it builds a list of one or more imaging passes for the print engine to perform **140**. The first is the primary imaging pass. If no jets are disabled **122**, then only this pass is added to the list and all jets are used. If one or more jets are disabled, then the primary imaging pass is placed in the list using all but the disabled jets **124**. The image rendering and handling software then examines which jets are disabled and determines the minimum number of secondary imaging passes to perform.

[0027] If all disabled jets can be substituted using neighboring jets to the right of the disabled jets **126**, a single secondary imaging pass is added to the list. The starting position **80** of the printhead will be to the left of the primary imaging pass such that substituting jets to the right of the disabled ink jets will be starting at the same position that the disabled ink jets of the primary imaging pass started. This is called a *left fill* imaging pass **128** as shown by the diagram **88** in **FIG. 5** and illustrated by ink jets **74** in **FIG. 4**.

[0028] If a single *left fill* imaging pass cannot substitute all disabled jets, then a check is made to see if all disabled ink jets can be substituted using neighboring ink jets to the left of the disabled ink jets **130**, and if so, a single secondary pass is added to the list. The starting position **78** of the printhead will be to the right of the primary imaging pass such that the substituting jets to the left of the disabled jets will be starting at the same position that the disabled jets of the primary imaging pass started. This is called a *right fill* imaging pass **132** as shown by the diagram **84** in **FIG. 5** and illustrated by ink jets **70** in **FIG. 4**.

[0029] If a single *right fill* imaging pass is insufficient then a combination **134** of the *left fill* and *right fill* imaging passes will be added to the list, where some of the

disabled jets are substituted by the left fill imaging pass **136** and the remaining portion is substituted by the right fill imaging pass **138**.

[0030] The order of selecting the fill is irrelevant. Left fill may be chosen and/or performed before or after right fill. Depending on the availability of neighboring jets and the limitations of head travel, it may not be possible to substitute all failed jets.

[0031] Additionally, it should be noted that depending on the color of the failed jet, it is possible to substitute the jet with a combination of different colors. An example of this is to use a combination of Cyan, Magenta, and Yellow to replace a failed Black jet with a Composite Black. By way of example and not of limitation, if the failed jet is black, it can be filled in with a combination of cyan, magenta and yellow without additional imaging pass. When the user has enabled the methods for jet replacement on a printer (i.e. – recognizing image artifacts on the printed page indicating a failed jet and then replacing it with a neighboring jet) then the printing speed is reduced approximately proportional to the number of passes required. For example, a second imaging pass will require approximately twice as long to print the image as compared to a single pass image. Therefore, by preprocessing or by doing parallel processing of the image during printing it may be determined if the jet substitution mode has been enabled and whether a replaced jet is used in the image. If the replaced jet is not used, then the second or multiple additional passes are not required. This will result in printer throughput that is only slightly slower than the original throughput, due to the additional image processing. The user may enable and disable the image rendering and handling software through the front panel. For example, if a new head is installed, all jets will be enabled automatically allowing full speed printing.

[0032] The actual methods of detecting and replacing jets can have other embodiments depending on the architecture of the printer. For example, in a printer architecture with additional print head travel, it is possible to position the printhead in the secondary pass to fill in multiple jets without requiring a third pass.

[0033] The claims, as originally presented and as they may be amended, encompass variations, alternatives, modifications, improvements, equivalents, and substantial equivalents of the embodiments and teachings disclosed herein, including those that are presently unforeseen or unappreciated, and that, for example, may arise from applicants/patentees and others.